ENERGY OF A PEANUT
AN EXPERIMENT IN CALORIMETRY

PURPOSE: To investigate thermochemical concepts such as calorimetry through simple food energy calculations.

INTRODUCTION:

Calorimetry is a technique that is used to determine the heat involved in a chemical reaction. When determining the heat of combustion of a substance or the caloric value of foods, the measurements are often made using a *bomb calorimeter*. In this device, the weighed sample is placed in a heavy steel container called a *bomb* and the atmosphere of the bomb is filled with pure oxygen. The bomb is then placed in a well insulated container called a *calorimeter* which has been filled with a measured amount of water. The sample, in the pure oxygen atmosphere, is ignited by an electric spark and the heat generated by the burning sample warms the bomb and the surrounding water. At equilibrium, both the bomb and the water will be at the same temperature.

Using the law of conservation of energy:

Heat evolved by the reaction = Heat absorbed by the water + Heat absorbed by the bomb

or, in equation form:

$$q_{reaction} = -(q_{water} + q_{bomb})$$

(where *q* is the symbol for heat)

The $q_{reaction}$ has a negative value because the combustion reaction is *exothermic* (i.e., it releases energy to the surroundings). The q_{water} and the q_{bomb} are calculated from the temperature change of the water and the bomb and the specific heat of the water and the bomb. The total gives the heat of combustion of the sample that was used.

In this experiment, the energy of a peanut, or other sample, will be determined using a simplified set-up. The peanut will be burned in air, instead of pure oxygen. Instead of a heavy metal bomb, a metal can, is used. To eliminate the determination of the specific heat of the metal can (the heated needed to heat the metal that composes the can), the experimental conditions are modified change the temperature of the cans contents, water. This will allow us to calculate heat production using the specific heat of water, 4.184 J/g^oC. The heat evolved by the burning peanut transfers to the water and can be measured as temperature change.

After determining the energy of a peanut, the procedure will be repeated using other snack foods.

A. MATERIALS NEEDED:

Calorimeter metal can and Styrofoam
wire stand to hold the sample
110ºC thermometer
graduated cylinder, 50 or 100-mL
tongs or forceps
funnel
peanuts
3 different snack foods such as Doritos , pop corn, corn nuts, potato chips, etc...

B. SAFETY PRECAUTIONS:

Wear safety goggles do not touch anything hot..

CAUTION – HEALTH HAZARD: This procedure involves burning nuts. If you are allergic to nuts, or have any severe food allergies, inform your instructor immediately so that you may be excused from this experiment. Do not stay in the laboratory.
Do not eat any of the foods used in this experiment. It is assumed that they may be contaminated with laboratory chemicals.

C. EXPERIMENTAL PROCEDURE:

1. Obtain a metal can. If necessary, wipe any carbon deposits off the bottom of the can using a paper towel.

2. Set up the apparatus as shown by Mr. Golden. Use a large adjustable clamp to hold the metal can. Place a metal stand for holding the peanut on the base of the ring stand. Loosen the clamp and move the metal can off to the side of the apparatus.

3. Select a sample and attach it to the sample holder, weigh it, and record its mass.

4. Add 100ml of DI water to can.

5. Place Styrofoam cup upside down over can with Celsius thermometer submerged to within 2cm of bottom of can.

6. Wait 1.0min and record temperature of water. (T_i)

7. Place the and stand under the calorimeter and light it using a wooded splint or Bunsen burner. Move the can over the burning peanut/ sample and position it so that the top of the flame just touches the bottom of the can. Allow the peanut/ sample to burn completely. If the flame goes out and the peanut/ sample is not at least 70% burned, relight the peanut/ sample.

8. Remember to move the can away from over the peanut when relighting it.

9. Once the peanut/ sample stops burning record the highest temperature observed. (T_f)

10. After the food material, is burned, some charcoal remains. Carefully transfer the remaining material and sample holder to the cale and weigh it.

11. Determine the mass of the remaining material. The mass of sample burned is equal to the initial mass of the peanut/ sample minus the mass of the remaining material.

12. Repeat the procedure with another peanut/ sample previously used.

13. Select two (2) different samples from the snack food you brought and repeat the procedure twice more using the food sample.

D. CALCULATIONS:

In this experiment, heat is measured in calories. One calorie is the quantity of heat needed to raise the temperature of one gram of water by 1ºC. We will be measuring the temperature change of 100ml of water. From the temperature change of water we can calculate the quantity of heat (or "energy") produced form the food sample. Notice below that the calculations will give a heat (q) value with units of Joules, we need calories.

$$1cal = 4.184J$$

The density of water is 1.0 g/cm^3, so it is assumed that the volume of water in mL will be equal to the mass of the water in g.

$$1 \text{ mL } H_2O = 1 \text{ g } H_2O$$

The heat produced by the burning sample is calculated by the equation:

$$q_{sample} = m_{water} \times C_{pwater} \times \Delta T$$

q_{peanu} = heat produced by the peanut in calories
m_{water} = mass of the water in g (this is equal to the volume of the melted ice in mL)
C_{pwater} = specific heat of water 4.184 J/g^{o}C

Notice the above calculations will give a heat (q) value with units of Joules, we need calories.

$$1\text{cal} = 4.184\text{J}$$

The heat, in calories, generated by a one gram sample is calculated by the equation:

$$q = q_{peanut}/m_{sample}$$

q = heat generated per gram of sample in calories
q_{sample} = heat produced by the burning sample in calories
m_{sample} = mass of the sample that burned in grams

Calculate the *nutritional calories* or *kilocalories* available from the samples you used. To calculate kilocalories, divide the heat generated by 1 gram of sample by 1000.

kilocalories = q/ 1000 *cal kcal*

q = heat generated per gram of sample in calories
To calculate "Calories" per gram (from label)
"Calories" per gram = "Calories" per serving size
Serving size in g

E. DATA AND RESULTS

Experimental Data	**Peanut**		**Other Snack Sample**	
	Trial 1	**Trail 2**	_____	_____
Mass of sample	g	g	g	g
Mass of remaining material	g	g	g	g
Mass of sample that burned	g	g	g	g
Initial Temperature	°C	°C	°C	°C
Final Temperature	°C	°C	°C	°C
Change in Temperature water (ΔT)	°C	°C	°C	°C
Volume of Water	ml	ml	ml	ml
Mass of water	g	g	g	g

Experimental Calculations

Heat produced by sample Joules	J	J	J	J
Heat produced by sample in calories	cal	cal	cal	cal
Food calories (Cal) (kcal=Cal)	Cal	Cal	Cal	Cal
Heat produced by 1 gram of sample in Cal (kcal)/g	Cal/g	Cal/g	Cal/g	Cal/g
Serving size (from label)	g	g	g	g
"Calories" per serving size (from experiment)	Cal	Cal	Cal	Cal
"Calories" per serving size (from label)	Cal	Cal	Cal	Cal
"Calories" per gram (from label)	Cal/g	Cal/g	Cal/g	Cal/g

Show all your calculations

F. QUESTIONS:

1. What is being transferred to the water in the metal can during the reaction?

2. What errors, at least three (3), do you encounter in these procedures and how do they affect the results (i.e., a large effect or a small effect)?

3. How does your value for the caloric energy of a peanut (or other food) compare to the label information?

4. Calculate the "calories per gram of fat" (from the label information) for the foods you tested.

$$\frac{calories\ from\ fat}{grams\ of\ fat}$$

5. What in the peanut was "burning?"